UNMANNED AERIAL LOGISTICS VEHICLES:
A CONCEPT WORTH PURSUING?

A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE
General Studies

by

JOHN V. McCOY, MAJ, USA
M.S., Florida Institute of Technology
Fort Lee, Virginia, 2002

Fort Leavenworth, Kansas
2003

MASTER OF MILITARY ART AND SCIENCE

THESIS APPROVAL PAGE

Name of Candidate: MAJ John V. McCoy

Thesis Title: Unmanned Aerial Logistics Vehicles: A Concept Worth Pursuing?

Approved by:

____, Thesis Committee Chair
LTC Kenneth E. Long, M.S.

____, Member
MAJ Marcus D. Majure, M.A.

____, Member, Consulting Faculty
Ronald E. Cuny, Ed.D.

Accepted this 6th day of June 2003 by:

____, Director, Graduate Degree Programs
Philip J. Brookes, Ph.D.

The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

UNMANNED AERIAL LOGISTICS VEHICLES: A CONCEPT WORTH PURSUING?, MAJ John V. McCoy, 58 pages.

Presently, United States Army battlefield supply distribution does not involve unmanned aerial logistic vehicles. The United State military's *Joint Vision 2020* and its tenet of Focused Logistics provide vision for force development allowing for the exploration of the unmanned aerial logistics vehicles concept. This thesis explores the primary research question: Could the United States Army benefit by pursuing an unmanned aerial logistic vehicle concept? Secondary questions are defined and addressed: (1) Can unmanned aircraft realize a logistic supply delivery process? (2) Which of the possible unmanned aircraft processes is the recommended process? and (3) Which existing logistic processes are to be improved? All questions are explored by applying the Wisconsin 7-Step Problem-Solving Strategy: stating the problem, determining solution criteria, gathering needed information, generating potential solutions, comparing solutions and the problem, selecting the solution, and preparing communications. Multiple unmanned aerial logistics concept options provide potential solutions involving unmanned fixed-wing aircraft, rotary-wing aircraft, blimps, and precision airdrop systems, alone or in combination, and each yielding potential benefits when compared to existing supply distribution processes. Were an unmanned aerial logistic vehicle system actualized, some part of the United States Army's existing supply distribution process could be improved.

ACKNOWLEDGMENTS

The utmost in appreciation is extended to the many who contributed directly or indirectly to the completion of this effort: to Dr. Philip J Brookes for working over many years to expertly structure this degree program in a way well suited to the particular needs of this school's students, to the thesis committee of LTC Kenneth Long, MAJ Marcus Majure, and Dr. Ronald Cuny for providing the en route azimuth checks and style recommendations required produce the finished product, to Ms. Helen Davis for providing needed meticulous and detailed format reviews and corrections to the many drafts submitted, to LTC Edward Bowie who as the primary instructor encouraged me early on in the course to, in general, take a stand and write what I think about the things which I feel are important keeping the academic fire burning hot enough to pursue this effort through to completion, to LTC Daniel Hodges who, through professionalism set a positive example of military service conducted in the academic environment, and to my family for providing editorial review and accepting my time put towards this effort as time well spent.

TABLE OF CONTENTS

ACRONYMS

CRW	canard rotor wing
GPS	Global Positioning System
LTL	less than truckload
MREs	Meals-Ready-To-Eat
UAV	unmanned aerial vehicle
PAM	pamphlet
SAR	search and rescue
SASS LITE	small airship surveillance system, low intensity target exploitation
SEAD	suppression of enemy air defense
TBM	tactical ballistic missile
TCT	time critical targets
TRADOC	Training and Doctrine Command

ILLUSTRATIONS

TABLES

CHAPTER 1

INTRODUCTION

> If you want to succeed you should strike out on new paths rather than travel the worn paths of accepted success.
>
> John D. Rockefeller Sr.

An Opportunity for Innovation?

Multiple friendly ground task forces have just completed sweeping maneuver to their preferred assault positions designed to present the enemy with multiple dilemmas from multiple directions. Each absorbed enemy resistance as it went; each stretched its distances from its base to the limit. Equipment and vehicles experiencing wear and damage have been identified. Personnel injuries have been reported. Ammunition supplies consumed in the process have been monitored. Rather than execute a time-intensive resupply, rearm, and refit operation forcing logistics elements to use extended ground lines of communication, unmanned logistic aerial vehicles are launched from air and ground ports to fly circuit routes over customer after customer, depositing required supplies via guided parachute airdrop delivery to within ten meters of their required locations. The friendly commander has retained momentum and initiative, and the logistic and operational stage has been set for a decisive operation.

Research Questions

The research question asks: Could the United States Army benefit by pursuing an unmanned aerial logistic vehicle concept? While executing this research project, three secondary research questions were examined: (1) Can unmanned aircraft realize a logistic supply delivery process? (2) Which of the possible unmanned aircraft processes is the

recommended process? And (3) Which existing logistic processes are to be improved? The first secondary question went to the viability of applying unmanned aircraft technology to logistic processes. The second question helped determine of all possible options, which was of most value. The third question addresses which, if any, logistic processes executed could be substituted with unmanned aerial process to yield benefits.

Background

The US military recognizes the need to prepare now for an uncertain future. The Department of Defense's *Joint Vision 2020* provides vision for US military force development as the military prepares for the future over the next twenty years. In *Joint Vision 2020,* future military forces retain the primary purpose of fighting and winning the nation's wars. However, *Joint Vision 2020* asserts that today's forces must transform into future forces to properly adapt to the changing and increasingly complex twenty-first century strategic environment.

The overall goal of *Joint Vision 2020* transformation is the creation of a force dominant across the full spectrum of military operations. By design, the Joint Vision is an outline fleshed out over time as concepts develop until its actualization in the year 2020. The *Joint Vision 2020* strategy will develop a new level of joint interoperability, including a force that accepts, expects, and encourages cross-service interdependence and operational integration. *Joint Vision 2020* also expects new dimensions in robotics to dramatically increase the capability of the 2020 joint task force over what is available today.

Focused Logistics is an operational concept of *Joint Vision 2020* to be expanded. This research paper explores the focused logistics tenet of joint deployment/rapid

distribution, with emphasis on the potential for logistic application of unmanned aerial vehicles. Unmanned aircraft may answer expected logistic needs on future battlefields possibly yielding benefits of simplicity, reliability, flexibility, lift capability, interoperability, asset visibility, reduced risk, and reduced cost.

Future military logisticians are to use focused logistics to deliver just the right amount at just the right time to just the right place on contiguous or noncontiguous battlefields. Even though the US is risk adverse concerning loss of life, situations may dictate that logistic lines of communication traverse unsecured areas. The benefits of unmanned resupply aircraft may exceed the benefits of current air resupply systems involving manned C-130, C-17, C-5, C-40A, UH-60, and CH-47 aircraft. Unmanned resupply aircraft may even yield benefits exceeding those of existing manned ground resupply systems.

The Significance of the Study

This research may help define the United States military's focused logistics tenet of *Joint Vision 2020* while yielding significant future military benefits. Unmanned logistic aircraft could potentially reduce risk of human life in combat operations, reduce logistic footprint in future theaters of operations, and improve effectiveness and efficiency.

The use of unmanned logistic aerial vehicles may answer the question of how to effect "less-than-truckload" delivery of supplies throughout a noncontiguous battlefield without risking transportation assets and without increasing the logistic footprint. This process may additionally enhance logistics-over-the-shore throughput. Significant benefits in many areas may be possible when compared to the necessary investment.

Joint Vision 2020's focused logistics may be realized in part by unmanned logistic aerial vehicles.

Limitations

Future military logistic requirements and the projected capabilities of unmanned aircraft were explored. Processes of manned loading of supplies onto unmanned logistic aerial vehicles, and manned recovery of supplies or manned unloading of unmanned aircraft were addressed. Processes involving both aerial resupply and resupply involving the landing of the unmanned aircraft in the vicinity of resupply area were also addressed. The following types of unmanned aircraft were considered: helicopters, fixed-wing aircraft, and blimp-like aircraft, each used in conjunction with navigation-guided parachute systems. Issues of engineering specification compatibility between the unmanned aircraft and the supplies to be delivered were addressed. The possibility of providing intransit visibility and executing en route rerouting of supplies was explored. This research also addresses the potential for unmanned aerial vehicles to execute discrete delivery while finding and servicing multiple customers. Concerns about airspace control are explored. Also addressed are current military logistic practices and equipment to be improved by unmanned logistic aerial vehicle processes.

Delimitations

This research effort is limited in scope to exclude certain aspects related to the research topic. This research does not address bulk cargo resupply. This research also does not explore the many variables involved in assessing the feasibility of the United States military completing a material development and fielding process before 2020. This concept does not address any use of winged creatures, such as carrier pigeons delivering

messages or small bits of software, in any considered system. This research further does not explore survivability of unmanned logistic aerial vehicles on future battlefields. Finally, this research only explores and presents information of an unclassified nature.

Assumptions

Research proceeded after making two assumptions. The first assumption was that an unmanned aerial resupply process could potentially include manned loading of supplies onto the unmanned logistic vehicles. The second assumption made was that manned recovery of supplies or manned unloading of unmanned aircraft could be part of the process. The third assumption made was that any required on-the-ground rigging of airdrop supplies would not have to be automated, and that personnel would execute this portion of any process considered. These assumptions allowed the research to proceed without requiring a time-intensive and complicated examination of robotic loading and unloading system implications.

Operational Definitions of Key Terms

Bulk Cargo. That which is generally shipped in volume where the transportation conveyance is the only external container; such as liquids, ore, or grain.

Focused Logistics. The fusion of information, logistics, and transportation technologies to provide rapid crisis response, to track and shift assets while en route, and to deliver tailored logistics packages and sustainment directly to customers at the strategic, operational, and tactical level of operations.

Footprint. A measure of space that is the amount of personnel, spares, resources, and capabilities physically present and occupying space at a deployed location.

Full-Spectrum Operations. Full-spectrum operations include offensive, defensive, stability, and support operations. Army forces are expected to accomplish missions in any combination of these operations.

Joint Deployment and Rapid Distribution Process. The process of moving multi-Service forces to an operational area coupled with the accelerated delivery of logistics resources through improved transportation and information networks providing the warfighter with vastly improved visibility and accessibility of assets from source of supply to point of need.

Less than Truckload (LTL). A quantity of freight less than that required for the application of a truckload rate.

Lines of Communication. Routes, either land, water, or air, that connect an operating military force with a base of operations and along which supplies and military forces move.

Noncontiguous Areas of Operations. Areas of Operations that do not share a boundary.

Theater of Operations. A subarea within a theater of war defined by the geographic combatant commander conducting or supporting specific combat operations.

Throughput. Bypassing intermediate supply points when distributing supplies from ports to enduser customers.

Unmanned Aerial Vehicle (UAV). A powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload.

After defining the research questions, and after making assumptions, limitations, and delimitations, a review of the literature related to the unmanned aerial logistic vehicle concept was conducted, and results are presented in chapter 2.

CHAPTER 2

REVIEW OF LITERATURE

Research began with a review of existing literature related to the primary research question, Could the United States Army benefit by pursuing an unmanned aerial logistic vehicle concept? The literature review included topics associated with the three secondary research questions: (1) Can unmanned aircraft realize a logistic supply delivery process? (2) Which of the possible unmanned aircraft processes is the recommended process? And (3) Which existing logistic processes are to be improved?

Summary of Existing Literature

The current literature does address unmanned aerial vehicles and resupply by air. The literature also addresses the past history of unmanned aerial vehicles and the history of aerial resupply. Further, the literature suggests future employment options for unmanned aerial vehicles and future execution options for aerial resupply.

Literature related to the secondary question, Can unmanned aircraft realize this process? The following three sources provided information concerning unmanned concepts that may provide a solution to the primary question, Could unmanned logistic aircraft improve military logistic processes?

In *War Machines - Air*, the surmised "Shape of War to Come" envisions: "A state of war where the machines will fight it out while personnel become redundant. Undoubtedly, as in industry, complete automation is the ultimate development" (Octopus Books 1977). This author's assertion, if true, would justify the examination of using unmanned systems to execute battlefield functions now executed by manned systems, as

this research project does concerning its examination of potential roles for future unmanned logistic aircraft.

Advantages to be gained by replacing manned systems with unmanned systems are discussed in *Reducing the Logistics Burden for the Army After Next, Doing More With Less*, which proposes the use of unmanned vehicles "can reduce the fuel demand of battlefield vehicles primarily by decreasing the amount of vehicle structure (hence weight) requirements for substructures, such as the cockpit and the protection subsystem (armor)" (National research Council 1999).

In the *Role of Unmanned Aerial Vehicles in Future Armed Conflict Scenarios* (Longino et al. 1994) United States Air Force cultural resistance to unmanned aerial vehicle (UAV) development is described as emanating from narrow views about UAVs, difficulty in gaining political support for expensive manned aircraft in contrast to cheaper UAVs, and a belief that UAVs are unnecessary and redundant in light of manned aircraft capabilities. Lieutenant Colonel Longino concludes that joint benefits can be reaped from UAV programs, including the potential that Air Force fighter wings themselves could benefit from UAV reconnaissance augmentation.

<u>Literature related to the secondary question, Which of the unmanned aircraft processes is the recommended process</u>? The following four sources provided information concerning processes that may provide a solution to the primary question, Could unmanned logistic aircraft improve military logistic processes?

Present day UAV use is detailed in the article "UAVs - A Revolution in Aerial Warfare Continues" (Omholt 2002). The article details present day UAV innovations involving the mounting of Hellfire precision weapons on Predator UAVs for use in

destroying enemy armored vehicles in Afghanistan. The author draws a parallel between the early World War I military use of manned aircraft solely as reconnaissance vehicles, which was followed by rapid, prolonged, and full-mission expansion for manned aircraft, and today's expansion of unmanned aircraft roles beyond solely missions of reconnaissance.

In *Brassey's Unmanned Aircraft* (Reed 1979) the author outlines American UAV projects circa 1980 involving the development of small antiradar UAVs capable of loitering in the vicinity of dormant enemy radar systems and then Kamikaze-like, dive-bombing into enemy radars that later emitted radar signals. To overcome expected range limitations, the system of small UAVs was to be packed into a delivery rocket, launched to enemy territory, and directed by remote signal to "spawn" its load of harassment remotely piloted vehicles which would then fly programmed routes to their target areas. Prototypes also were tested where a bomb-shaped pod was released from below an F-4 Phantom, and near the end of its trajectory, a drogue parachute deployed to slow its descent. Later another parachute deploys that extracts the UAV from the pod to where its wings can expand. The UAV then flies off to its target. The author describes how modern commercial airliners are practically operated by machine rather than man with the prevalent use of redundant autopilot systems for takeoff, cruising, and landing. Were social norms not to require piloted commercial airliners, only small changes would be necessary to automate the commercial airline industry yielding economic benefits to airline corporations. The author describes a likely scenario on a future battlefield in which swarms of opposing air and ground remotely piloted vehicles clash in devastating battles in which manned aircraft are too risky to employ. Rather, man's participation is

limited to remotely piloted vehicle control from cool, quiet, air conditioned bunkers miles from the battlefield, watching battle progress on consoles as they control the battle through joysticks and keystrokes.

"Up Ship!" A History of the U.S. Navy's Rigid Airships 1919-1935 (Robinson and Keller 1982) recounts a detailed history of U.S. Navy zeppelin aircraft experimentation ending in 1935. Rigid airship zeppelins were designed to support reconnaissance efforts and included technological innovations for air-to-zeppelin and zeppelin-to-air mechanisms. A crewman routinely parachuted from zeppelins to assist in ground docking. This led to innovations involving safer gliders being employed from the zeppelins to get landing crewmen to the ground in advance of the zeppelins themselves. As well, the use of zeppelins as airborne aircraft carriers was developed using zeppelins with airplane cargo areas to hold up to four small aircraft. Trapezelike winch systems would lower the aircraft for launch. To "land" on the zeppelin, returning aircraft would approach and then hook on to the trapeze dangling below the zeppelin and then be hoisted up into the cargo bay. This system would allow the limited range of the small aircraft to be overcome by being carried in the zeppelin, and the observation standoff of the zeppelin to be overcome by the smaller aircraft. Successful exercises were conducted employing this system to track naval formations under radio silence undetected. However, in 1935, aircraft advances outpaced zeppelin advances, and seaborne carriers gained the favor of the Navy. Thus, US military zeppelin development was halted. Such was the situation until 1989, when the US Army led development of the ninety-two foot by thirty-two-foot small airship surveillance system, low intensity target exploitation (SASS LITE) for use in long-endurance surveillance, reconnaissance, electronic warfare,

communications relay, search and rescue, environmental sensing, police functions, and commercial television broadcast.

The article "Emerging Technology in Airdrop Operations" (Davis et al. 1997) discuss parachutes enhanced with the global positioning system (GPS) and manual guidance capability as being at a cost unacceptable for one-time-use humanitarian relief operations.

<u>Literature related to the secondary question, Which military logistic processes are to be improved?</u> The following six sources provided information concerning military processes being made that may provide a solution to the primary question, Could unmanned logistic aircraft improve military logistic processes?

The "Aviation Week & Space Technology and Association for Unmanned Vehicle Systems International 1997-98 International Guide to Unmanned Vehicles" (*Aviation Week* 1997) recounts the history of unmanned aerial vehicles from their World War I emergence as drones. Also recounted is the progression of unmanned aerial vehicles from United States World War II bomb-laden airplanes flown, put on target, and then jumped out of, through an evolution of complex training drones for use in targeting. During the Korean War era, Army-driven unmanned reconnaissance aerial vehicle technology emerged and evolved in parallel with target drone development. The 1960 U2 downing incident sparked United States Air Force unmanned reconnaissance aircraft development, though opponents of unmanned aircraft opposed the idea. In the Viet Nam era, unmanned aircraft were secretly used to reconnoiter, conduct electronic warfare, drop chaff, drop leaflets, and act as a decoy simulated U2. Concepts of unmanned drone recovery in flight by CH-3C helicopters evolved, as did engine performance, as did in-

flight drone launch technology as executed from DC-130 aircraft. In 1976, for budgetary considerations, the United States Air Force scrapped all unmanned aircraft development. Even though throughout the decades leading up to 1981, the US had spent billions of joint developmental spending for remotely piloted vehicles, in 1981 not one remotely piloted vehicle was operational in the US. Recent revival of UAV technology has been in the form of Pioneer, Predator, Global Hawk, Darkstar, and Outrider development for executing reconnaissance and electronic decoy missions. Future UAV applications are surmised to encompass unmanned combat air vehicles, reviving an old idea for use in dangerous ground attack missions, but also for innovative use of replacing fighter aircraft, while the role as drone is expected to evolve into guided missile simulators. Unmanned helicopter technology is also being developed employing vertical-launch and vertical-landing technology.

Twenty-first century UAV technology enhancements are addressed in the *Unmanned Aerial Vehicles, DOD’s Demonstration Approach Has Improved Project Outcomes* (United States General Accounting Office 1999) including the Darkstar program. The Darkstar UAV program is one of the most technologically advanced UAV programs. A program objective was to develop a UAV employing stealth technology. The program has since been scrapped due to monetary constraints.

Victory Systems, a producer of unmanned aircraft, lists on its company internet home page the following examples of military and military-related unmanned aircraft missions: surveillance and reconnaissance; preparation of the battlefield while en route; surface search and correlation; battle damage assessment; miniature scout helicopter (team with attack helicopter); unmanned attack helicopter (team with manned attack

helicopter or operate independently); naval gunfire support; counter-cruise missile operations; observe own forces landing; to prevent fratricide; chokepoint monitoring; force protection; communications and radar jamming; sensor grid deployment and monitoring; supply and logistics to fielded forces; border monitoring (large peacetime demand); antisubmarine warfare (dipping sonar, etc.); reactive surveillance; precision strike: suppression of enemy air defense (SEAD) tactical ballistic missile (TBM) time critical targets (TCT); search and rescue (SAR) operations; medical supply delivery and wounded recovery; prisoner extraction; casualty extraction; communications relay; signal intelligence collection and electronic warfare; radar and communications jamming; mine hunting, clearing, and avoidance; range safety monitor; special operations; refueling manned and unmanned ground combat vehicles; and emergency extraction.

In the article “Is Battlefield Distribution the Answer?” (Abel 1997) Captain Abel suggests criteria for addressing the Army’s battlefield distribution concept include responsiveness (the distance between the authorized stockage list and the requesting unit and whether the supply support activity delivers supplies or requires unit pickup); transport capability (the availability and modes of transportation); stock control (the ability of the division materiel management center to redirect or laterally transfer repair parts among supply support activities); and personnel and equipment (the number of personnel and the amount of equipment required for an operation).

Ground-based distribution systems tend to form hub-and-spoke distribution networks, whereas aerial resupply vehicles have the capability of bypassing intermediate supply points when distributing supplies from ports to enduser customers. The publication *Exploring Microworld Models to Train Army Logistics Management Skills*

(RAND 2002) asserts there can be some potentially positive and negative aspects of a direct delivery system when compared to a hub-and-spoke delivery system. Response times to end user customers can be reduced, but at the risk of negative results where intermediate customers starve and increased transit times result in supply backups at ports.

TRADOC Pamphlet 525-77 Military Operations: Battlefield Distribution (TRADOC, 1998) addresses the delivery of military supplies as battlefield distribution. According to TRADOC Pamphlet 525-77, “Battlefield Distribution is a holistic concept of information exchanges, management procedures, functional organizational designs, and reengineered operational processes which enable U.S. forces to properly request, receive, redirect, track, distribute, control, and retrograde materiel, services, units, and personnel within a single distribution system” (1998, 3-1). The publication describes the US Army battlefield distribution system as a hub-and-spoke distribution system with increased throughput operations where shipments received at ports of debarkation can be throughput directly to customers.

Evaluation of Existing Literature

Various trends exist in the literature on the subject of unmanned aircraft concerning investment and the classification of work conducted on unmanned aircraft. The literature addresses advantages of unmanned aircraft while not addressing the use of unmanned aircraft for logistic resupply. The literature also suggests discarded concepts that may have the potential for future applications.

A clear pattern evident in the literature is that US military interest and investment in unmanned aircraft cycles from times of high interest to times of low interest. Interest

increased up through the 1960s, but then declined to the 1980s. The 1990s and current year evidence reveals an increase in interest and investment that continues through the present day.

Another pattern evident in the literature is that unmanned aircraft push the envelope of technological development, leading associated information to border between unclassified and classified information. Unmanned aircraft have earned the determination as classified for one of two reasons: either because of their uninvited employment over the territory of foreign nations or because of the level of advanced technology that they employ. Should the concept of unmanned logistic resupply aircraft be adopted, it is anticipated that its adoption would be unclassified due to its employment between friendly areas of suppliers and customers, as well as its lack of need for advanced technology generally requiring only that the aircraft takeoff and land while carrying supplies.

The literature also tends to reveal many potential advantages of expanding military use of unmanned aircraft. Possible advantages described in the literature include reduction in resources, reduction in risk to resources, and increases in efficiency. This research effort explores the expansion of unmanned aircraft missions to include military resupply on the battlefield to determine if similar advantages may exist in this realm.

The writers also provide discarded aerial concepts from history that were discarded due to varying special circumstances of their times. These same concepts may provide future possible solutions when applied to future employment of unmanned logistic resupply aircraft. The zeppelin example of an airborne aircraft carrier suggests the potential use of an unmanned airship serving as an aerial base for unmanned logistic

resupply aircraft. This suggestion based on existing literature will be explored by this research effort.

The writers of the literature are also helpful in suggesting criteria for evaluation of proposed concepts. The ideas found in the literature of responsiveness, transport capability, stock control, personnel and equipment, and distribution system point stockage levels will all be considered by this research effort, as criteria are determined.

A gap in the literature is a lack of exploration and development of the combination of the two concepts of unmanned aircraft and logistic resupply. Rarely are the two concepts ever discussed in the same forum. A discussion of expanding the mission sets of unmanned aircraft is prevalent, so it is expected that eventually, the literature will fully address the combination of unmanned aircraft and military resupply missions. This research effort helps close this gap in today's literature.

CHAPTER 3

RESEARCH METHODOLOGY

To answer the primary research question, Could the United States Army benefit by pursuing an unmanned aerial logistic vehicle concept? the Wisconsin 7-Step Problem Solving Strategy as outlined in *The Elements of Information Gathering, A Guide for Technical Communicators, Scientists, and Engineers,* by Donald E. Zimmerman and Michel Lynn Muraski (figure 1) is used. The same methodology is used to address the secondary research questions: (1) Can unmanned aircraft realize a logistic supply delivery process? (2) Which of the possible unmanned aircraft processes is the recommended process?, and (3) Which existing logistic processes are to be improved?

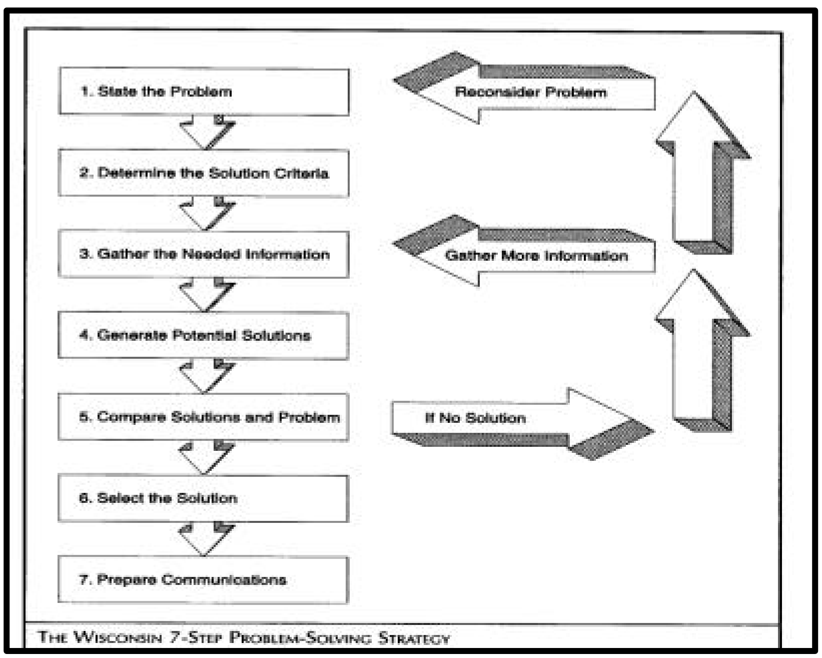

Figure 1. Diagram. *Source:* Donald E. Zimmerman and Michel Lynn Muraski, *The Elements of Information Gathering: A Guide for Technical Communicators, Scientists, and Engineers* (Phoenix, AZ: Oryx Press, 1995), 7.

Step 1, Stating the Problem, involved formulating the question: Could the United States Army benefit by pursuing an unmanned aerial logistic vehicle concept? After the problem was stated, three assumptions were made. The first assumption was that an unmanned aerial resupply process could potentially include manned loading of supplies onto the unmanned logistic vehicles. The second assumption was that manned recovery of supplies or manned unloading of unmanned aircraft could be part of the process. The third assumption was that any required rigging of airdrop supplies would not have to be automated, and that personnel would execute this portion of any process considered.

The process continued with Step 2, Determining the Solution Criteria. The solution criteria determined were:

1. Is the solution within the engineering realm of possible? This “yes or no” criteria is a screening criteria for which, if a process does not meet this criteria, then the process is excluded outright.

2. Does the aerial process remain unmanned? (This “yes or no” criteria is also a screening criteria.)

3. How well could the solution outperform existing resupply systems in the areas of reduced risk to assets, simplicity, reliability, flexibility, lift capability, interoperability, reduced footprint, responsiveness, and personnel requirements? A stronger performance in any of these subcriteria would make the process more preferred.

4. How well could the process be applied in a joint manner? The more a process has the potential for joint application, the more the process would be preferred.

5. How well can the process service multiple customers? A process’ ability to support a greater number of customers is more preferred.

6. How well can the process execute less-than-truckload delivery? The more a process could support less-than-truckload delivery, the more preferred the process.

7. How well can the process be executed in support of friendly forces operating on a noncontiguous battlefield? The more a process could provide support to a noncontiguous battlefield, the more preferred the process.

8. To what extent does the process complicate airspace control? For this criteria, the less a process complicated airspace control, the more preferred the process.

Having determined the solution criteria in Step 2, Step 3, Gathering The Needed Information, was conducted. Issues of battlefield environment, supply, demand, and customer characteristics were addressed. Capabilities of unmanned aircraft were explored. Included in this exploration were the engineering aspects of the relation between the unmanned aircraft and the supplies they were to deliver.

Different processes were explored to determine potential solutions to the problem. Two primary processes in particular were explored: (1) Is it possible for unmanned aircraft to land near their customers to effect delivery of supplies? and (2) Is it possible for unmanned aircraft to conduct aerial delivery of supplies to their customers? Each possible airdrop option was explored from free drop, to low altitude drop, to high altitude drop. Also researched were the expected sophistication of unmanned aircraft logistic missions. For example, could unmanned aircraft be rerouted in flight?

Future logistic requirements were then explored. Logistic functions were researched to determine if any were suitable for execution by unmanned aircraft. Suitable supply missions were explored in detail addressing supply length, width, height, weight, and quantity considerations.

Having completed the initial research, the following four possible solutions were considered.

1. Load-Take Off-Land-Unload. This process involves an unmanned aircraft being loaded with supplies at a source takeoff site. The aircraft would then fly to a landing area near the customer and land. The supplies would be offloaded, and the aircraft would then take off and return to any other source of supply, perhaps carrying backhaul cargo as the situation allowed.

2. Load-Take Off-Airdrop-Return. This process involves an unmanned aircraft being loaded with supplies at a source takeoff site. The aircraft would then fly over its customers and airdrop its supplies to customers on the ground. The aircraft would then return empty to the source takeoff site for repeated use.

3. Heavy-Lift Ship Loads, Takes Off, and Hovers: Smaller UAVs Deploy and Land. This process involves a heavy-lift ship loading with smaller UAVs and supplies, taking off, and stationing itself in a position in the air awaiting supply requests or orders. As orders are received, the heavy-lift ship deploys smaller UAVs carrying supplies that land near their customers. The UAVs then take off and return to the heavy-lift ship for future use.

4. Heavy-Lift Ship Loads, Takes Off, and Hovers: Smaller UAVs Airdrop and Return. This process involves a heavy-lift ship loading with smaller UAVs and supplies, taking off, and stationing itself in a position in the air awaiting supply requests or orders. As orders are received, the heavy-lift ship deploys smaller UAVs carrying supplies that then fly over their customers airdropping supplies. The smaller UAVs then return empty to the heavy-lift ship for future use.

Having generated four potential solutions in Step 4, Step 5, comparing the solutions and the problem, was executed. When each potential solution was compared to the problem's screening criteria, each solution proved viable. A discussion of each process' performance when considered for each screening criteria is provided at the beginning of Chapter 4, "Analysis." The research was then ready to proceed to Step 6.

Step 6, selecting the solution, was executed by comparing the possible solutions against each other and evaluating each against the problem's criteria determined in Step 2. The results of this comparison are detailed in the next chapter, Chapter 4, "Analysis," and the recommended solution to the research problem is discussed in Chapter 5, "Conclusions and Recommendations." Table 1 outlines how the potential solutions were to be assessed in accordance with the established criteria.

Table 1. Potential Solutions and Solution Criteria

	Potential Solutions			
Criteria in Order of Priority	**Solution 1:** Load-Takeoff-Land-Unload - blimp, helicopter, or plane	**Solution 2:** Load-Takeoff-Airdrop-Return	**Solution 3:** Heavy-lift Ship Takes Off and Hovers-Air Cargo Delivered Via Airdrop	**Solution 4:** Heavy Lift Ship Takes Off and Hovers-Smaller Delivery UAVs Airdrop and Return
reduced risk to personnel				
How well can the process be executed in support of friendly forces operating on a non-contiguous battlefield?				
responsiveness				
flexibility				
reduced footprint				
simplicity				
personnel requirements				
How well can the process service multiple customers?				
How well could the process be applied in a joint manner?				
How well can the process execute less-than-truckload delivery?				
To what extent is control of the process susceptible to enemy disruption?				
To what extent does the process complicate airspace control?				
reliability				
lift capability				

The rows of Table 1 were filled out using ordinal measures without specifying the specific magnitudes. Although for each criteria, the order of performance for each

potential solution is apparent, the following explanations specify to what specific aspects of the solution the criteria of Table 1 were applied. Results are provided in Appendix 1.

1. Reduced Risk to Personnel. This criterion assessed personnel risk to hazards encountered beyond the point of takeoff.

2. How well can the process be executed in support of friendly forces operating on a noncontiguous battlefield. This criterion assessed the process' ability to provide logistic support when no continuous accessible land mass is present between source of supply areas and customer areas.

3. Responsiveness. This criterion assessed for each process how fast unforecasted immediate requirements could be met. It assessed the time involved in meeting the immediate demand, a function of both how close to customers needed supplies would be and how fast the supplies can be moved to the customer.

4. Flexibility. This criterion assessed how many options for destinations each process had, how many multiple customer areas could be easily serviced, and how easily delivery destinations could be changed. Concerning destinations, if the process required destination airfields for delivery, then the process was considered less flexible than a process that could deliver to destination airfields and areas away from airfields. Concerning the number of multiple customers serviced, more customers able to be serviced resulted in greater means of flexibility between the designated customers. Greater ease of changing destinations resulted in better flexibility as processes with this capability can incorporate customer areas outside the set of planned customer areas that, with little notice, may need to be changed.

5. Reduced footprint. This criterion addressed the footprint required to support each process at the source of supply with a smaller footprint being more preferred.

6. Simplicity. This criterion assessed the number of moving parts involved in the process and the complexity of those parts' interrelationships. Because simple processes are easier to maintain and support with spare parts, the more simple a process is, the more preferred that process.

7. Personnel requirements. This criterion assessed how many personnel would be required to support the system to make the system perform, including personnel needed to sustain continued use of the process. The fewer people required the more preferred the process.

8. How well can the process service multiple customers. This criterion assesses how many customers can be serviced during each single execution of the process. Because time is required to execute each process, and because multiple customers are expected to have simultaneous supply demands, the more customers serviced by each iteration of the process, the more preferred the process.

9. How well could the process be applied in a joint manner. The more services that could potentially use and benefit from implementing the process, the more preferred the process.

10. How well can the process execute less-than-truckload delivery. Because a process that could provide less-than-truckload delivery would enhance existing distribution systems, the easier and more efficiently a process could execute less-than-truckload delivery, the more preferred the process.

11. To what extent is control of the process susceptible to enemy disruption. The less continuous ground control of unmanned aerial logistic vehicles required, the more preferred the process. As bursts of control signals are less susceptible to enemy disruption, the more a process could be controlled by bursts of control signals, the more preferred the process.

12. To what extent does the process complicate airspace control. The more pieces required to be moving in the air during execution of the aerial delivery system, the more complicated the airspace control requirements. Because many other airspace users must be coordinated to effectively execute combat operations, the less a logistic aerial delivery process complicates airspace control, the more preferred the process.

13. Reliability. Because customers may have life-or-death resupply needs, the more reliable the process, the more preferred the process. Systems that involve additional subsystems when compared to other systems will tend to have less reliability. Reliability was therefore assessed based on the number of subsystems involved in the process.

14. Lift capability. For some distribution processes involving certain commodities like fuel and ammunition, the more supplies provided to customers, the better. Therefore, for this criterion, the greater the lift capability of a single system, the more preferred the system.

The final step was to execute Step 7, preparing the communication. The communication media chosen for this research project was this written thesis.

<u>Methodology Strengths</u>. The Wisconsin 7-Step Problem-Solving Strategy strengths are it provides a logical framework within which to conduct research and it heads off tendencies to eliminate potential courses of action too early in the process. If

one takes each step of the process, the researcher is destined to arrive at an outcome worthy of the research effort. In the absence of any such logical approach, a researcher could potentially expend significant effort without ever producing any desirable result. As well, by not discarding any courses of action during the selection step until after all courses of action and criteria are fully developed, the process reduces the chance that a viable course of action in certain criteria would be discarded before the criteria were fully developed. Thus the process, by its design, increases the chance that a researcher will find a valuable solution to the research question at hand.

Methodology Weaknesses. The methodology does not take into account access to information, time constraints, or level of expertise of the user in its basic design. Implementation may require more steps than appear at face value. Potentially, a user may need to take additional steps to gain further education to understand required information. As well, a user may have to take additional steps to gain access to required information before sifting through the proliferation of information available in this modern age. The model does have shortcomings, as it addresses neither consideration.

CHAPTER 4

ANALSYIS

This chapter presents analysis of the research to address the primary research question, In the next fifteen years, could unmanned logistic aircraft improve military logistic processes? The analysis included the generation of four potential solutions and the performance of each process when judged against the problem's criteria. The analysis also addressed how the four potential solutions compared to an existing means of ground and air resupply.

PART I. FOUR POTENTIAL SOLUTIONS

Solution Process 1: Load-Take Off-Land-Unload

The research indicates that there are multiple types of UAVs with technology enabling them to take off, carry cargo, and land at a delivery site. The three UAV types with these capabilities are helicopters, planes, and blimps. There are existing unmanned helicopters, planes, and blimps all having cargo capacity enough to deliver at least thirteen cases of Meals-Ready-To-Eat (MREs) (total weight: 221 pounds; total cubic feet: 10.8, total number of meals: 156) that could supply a military unit of up to fifty personnel enough meals to provide each unit member a daily ration of three meals.

Military history is rich with scenarios where ground convoy routes have been interdicted by enemy activity and the routes have been closed pending clearance of the threat. In such a scenario, launching logistic UAVs to effect delivery would provide logistic units a solution to the tactical dilemma where delivering food or an equivalent weight and cube of medical supplies, critical parts, or ammunition must be accomplished,

but the ground risk to the logistic assets and the risks to the mission accomplishment are high.

This process (figure 2) stands out as the simplest involving the fewest system components of processes considered. The system involves only the unmanned logistic aerial vehicle and the cargo. To effect a single delivery, this process involves no parachutes, no multiple types of airframes, and no multiple unmanned vehicles. Due to the process' minimal system components, all else being equal, this process should exhibit the highest reliability based on an input of a set amount of time and equipment resources.

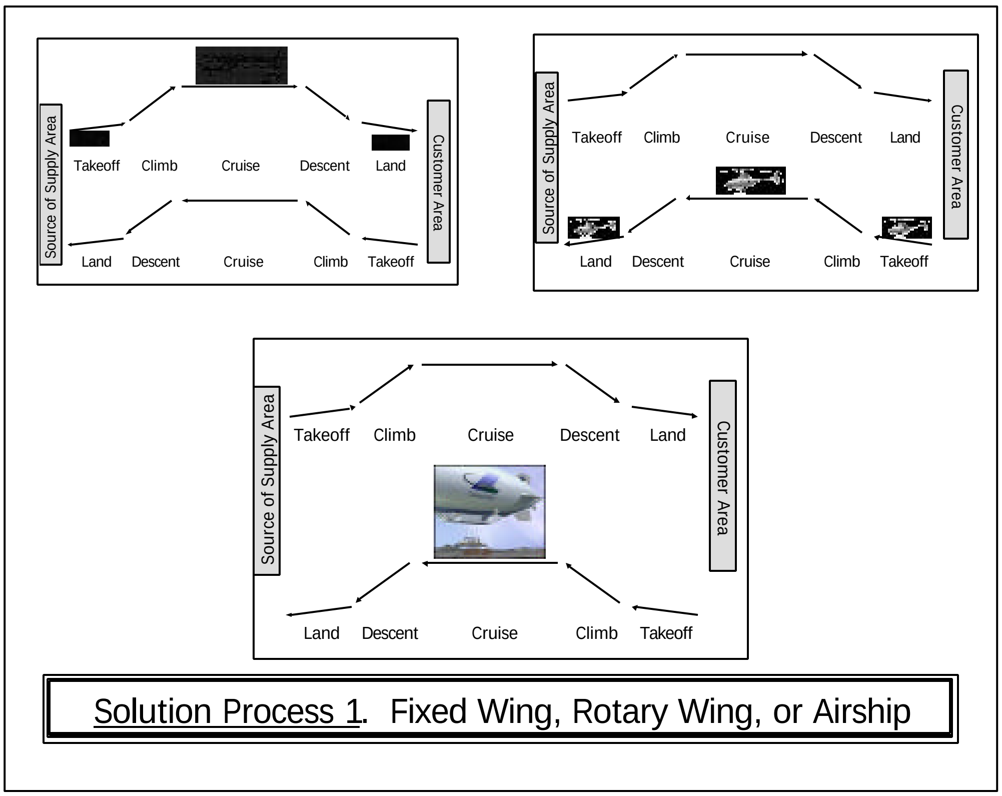

Figure 2. Solution Process 1. Load-Take Off-Land-Unload

The system's simplicity also provides for minimum footprint, requiring for a single delivery only the footprint of the airframe, its associated support needs, and its controller needs. No footprint is required for rigging support. No extensive footprint for large amounts of cargo are involved, and no footprint related to multiple vehicles is involved.

This process requires the least manpower for support. Only airframe maintenance and airframe control is required. No requirements exist for rigging, multiple airframe maintenance, or multi-type airframe maintenance.

This process also provides commanders the least complicated airspace control scenario. A single delivery involves only one route of flight of one vehicle. There are no requirements to deconflict airspace for multiple vehicles or multiple airdrop loads.

This process can effect less-than-truckload delivery without the need to commit a truck ground transport vehicle to effect the delivery of such a load. Current ground transport resupply methods require the dispatch of vehicles capable of hauling over a ton even though the required load may be as light as 200 pounds.

This process is expected to provide the same benefits of reduced risk to delivery personnel when compared to manned systems, the same opportunities for interoperability, and the same level of asset visibility as the other processes considered. This process also equally enables logistic resupply for a noncontiguous operation not capable of being supported by ground lines of communication (such as a multiple island operation scenario).

This process has the disadvantage of being the least responsive to unforecasted requirements. In response to an unforeseen requirement, time would have to be taken to

load cargo and identify a destination runway. This process cannot deliver supplies to areas lacking a landing runway.

Another disadvantage of this process is that it takes the most time to deliver supplies to multiple customers. A multicustomer delivery would involve taking time for a landing, taking time for an initial offload process, taking time for an additional takeoff, additional landings, addition offloads, and additional takeoffs, all in sequence. Other systems can service multiple customers in parallel.

Solution Process 2: Load-Take Off-Airdrop-Return

The research indicates that UAVs can effect airdrop and return to origin airfields. There are no insurmountable aerodynamic control problems associated with cargo loads departing unmanned aircraft while in flight, and there are technical means to control the ejection of airdrop cargo from distant ground-based control stations. Lightweight precision airdrop systems can guide small airdrop loads as light as 200 pounds to within 100 meters of their designated landing location from an aerial release point 20 kilometers offset from the target landing location. Cargo airframes used to airdrop multiple lightweight precision airdrop bundles can be equipped with automated takeoff, flight, and landing capability.

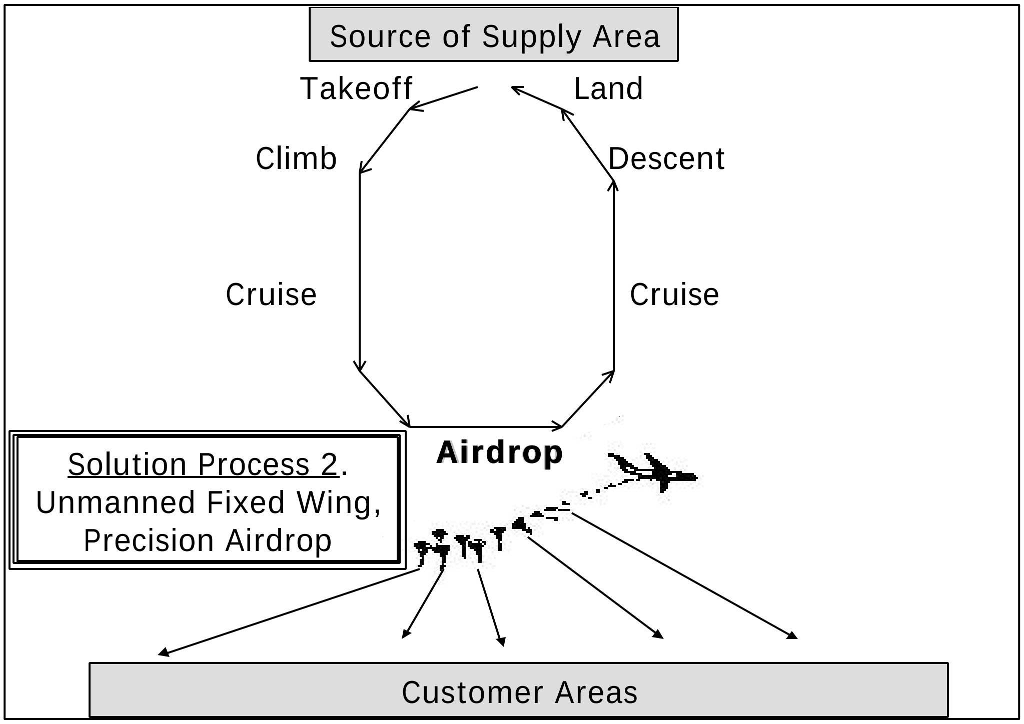

Figure 3. Solution Process 2. Load-Take Off-Airdrop-Return

With the scenario of the interdicted ground line of communication, this process could accomplish the mission and reduce UAV exposure over a flight distance and time of up to 40 kilometers of flight now executed by the load and the airdrop system, rather than by the UAV itself (twenty kilometers of final approach to the customer, and twenty kilometers of initial flight back to the source of supply).

This process has multiple advantages. The process is relatively simplistic when compared to hover and deliver systems considered with their multiple vehicles and multipart systems. However, the process is not as simplistic as the simple take-off-and-

land process. This takeoff and airdrop process does involve the added complexity of airdrop rigging requirements. Overall, this process is the second most simplistic system considered.

The reliability of this process is second best in the area of relative reliability. The process requires that a single aircraft and single airdrop system function to effect a delivery. The hover systems considered require additional systems to function and interrelate that should, given equal resources applied to the processes, result in their reduced reliability.

The take off and airdrop process involves relatively reduced footprint. Additional space for rigging and air item maintenance is all that is required in excess of the least footprint process considered. No additional footprint to support multiple aircraft or multiple airdrop rigging systems is required.

This process is second best of those considered in the area of responsiveness. In the event of an unforeseen requirement, all that is required to execute this process is the rigging and loading of the cargo. There is no need to identify a landing area in the vicinity of the customer. In the event there is no landing area in the vicinity of the customer, this process has the advantage of being able to effect delivery regardless via airdrop.

The only additional personnel required to execute this process are those required for rigging and air item maintenance. No additional personnel are required to service multiple types of aircraft or multiple airframes.

This process can well service multiple customers by flying in a circuit route, dispatching airdrop loads to customer after customer without the need to land near each customer, take time to execute an offload process, and then taxi into takeoff.

This process does add to the problem of airspace control more so than the process that does not involve airdrop. This process can involve multiple items of equipment falling through multiple air corridors requiring additional coordination with other military airspace users.

This process is expected to provide the same benefits of reduced risk to delivery personnel when compared to manned systems, the same opportunities for interoperability, and the same level of asset visibility as the other processes considered. This process also equally enables logistic resupply for a noncontiguous operation not capable of being supported by ground lines of communication (such as a multiple island operation scenario).

The greatest disadvantage of this process is the reduction in lift capability when compared to other systems. The reduction involved is that cargo weight that must be consumed by air item weight required to execute the precision airdrop. The other systems either do not need to consider air item weight or can lift and deliver more cargo along with the necessary air items using heavy lift vehicles.

Solution Process 3: Heavy-lift Takes Off and Hovers/Air Cargo Delivered via Airdrop

Solution Process 3 (figure 4) is supported by research that indicates that blimps can be constructed capable of airlifting up to 160 tons occupying a cargo area 50 meters by 8 meters by 8 meters. The research also indicates that blimps can be controlled from ground stations through takeoff, flight, and landing. Parafoil airdrop systems can be

constructed to deliver loads up to 21 tons in weight from aerial platforms to target areas on the ground using a glide ratio of 3 to 1 (a glide ratio of 3 to 1 enables supplies to be sent to the ground out to distances three times the altitude of the aerial platform at the time of airdrop cargo release).

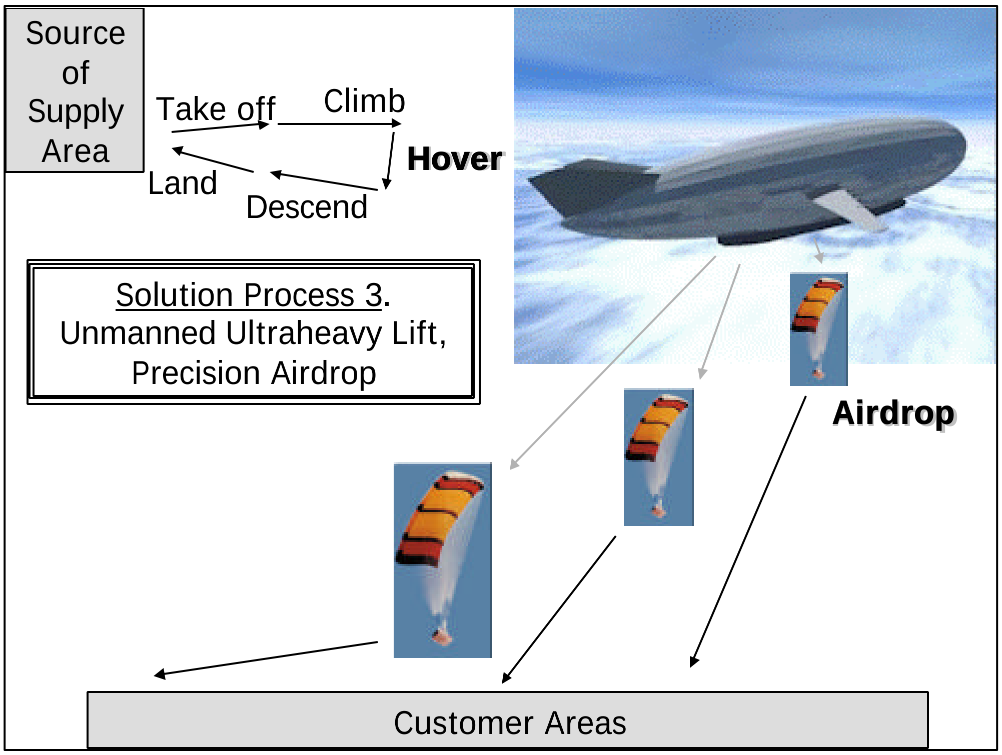

Figure 4. Solution Process 3. Heavy-lift Takes Off, Hovers/Cargo Delivered via Airdrop

With the additional cargo capacity of blimps considered, unmanned logistic aerial vehicles can now execute tactical scenarios of ammunition resupply. Should a situation require rapid fire of multiple artillery systems located in multiple areas in excess of their on hand ammunition stocks, and time does not allow the conduct of ground transport

travel and delivery, responsive emergency ammunition resupply via heavy lift unmanned logistic aerial vehicle coupled with heavy precision airdrop systems extends the time artillery systems can place fire effects on target areas to gain an advantage over the capabilities of enemy artillery systems.

The system does provide some increase in responsiveness when compared to the ground based processes. By having supplies in the air all the time as part of this process, the need to take time to load cargo in response to a sudden and unexpected request is avoided.

This process is expected to provide the same benefits of reduced risk to delivery personnel when compared to manned systems, the same opportunities for interoperability, and the same level of asset visibility as the other processes considered. This process also equally enables logistic resupply for a noncontiguous operation not capable of being supported by ground lines of communication (such as a multiple island operation scenario).

Despite providing relative increases in responsiveness, this process does not have any performance characteristic that is not exceeded by one of the other processes considered. This process would be a likely process of choice only if assets of the other processes were fully committed and this process provided supplemental capability.

This system rates worse than simpler take-off-and-land and take-off-and-airdrop systems in reliability, footprint, and personnel required. The system's multiple vehicles will complicate airspace control more so than the single vehicle processes, and the requirement for destination airfields limits the process' flexibility to responds to unforeseen requirements.

Solution Process 4: Heavy Lift Takes Off and Hovers/Smaller UAVs Airdrop and Return

Solution Process 4 (figure 5) is supported by research that indicates that blimps can be constructed to allow the launch and recovery of smaller aircraft from the blimps themselves. Smaller unmanned logistic aerial vehicles could be constructed capable of departing blimps, flying to designated release points, and discharging precision airdrop loads to customers on the ground. Those same unmanned aircraft could return, be hoisted back inside the cargo area of the blimp, and be automatically reloaded for subsequent use. Automatic reloading would be effected by mechanical conveyor belts depositing additional airdrop prepared cargo into the cargo bay of the unmanned aircraft, followed by the unmanned aircraft cargo hatch closing and securing the loads.

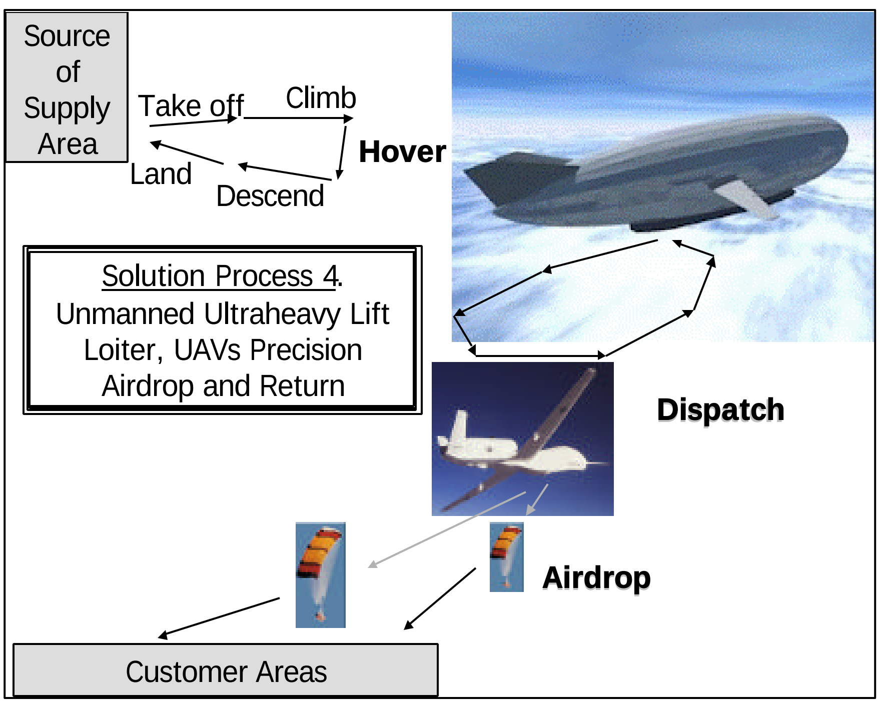

Figure 5. Solution Process 4. Heavy Lift Ship Takes Off and Hovers/Smaller UAVs Airdrop and Return

This process would provide the tactical advantage of extending the distance back from danger that unmanned logistic aerial vehicles, in this case unmanned supply blimps, could hover. Advantages gained from adding distance from counterair threats would enhance the survivability of the unmanned supply blimp systems.

This process is the best when considered against the criteria of responsiveness and flexibility. Supplies in the air not requiring time for loading, taxi, and takeoff reduce the order ship time when responding to unexpected supply requests. No need for the identification of landing zones near unexpected customers also reduces order ship time. Deliver via air drop allows delivery to customers including those not near suitable vehicle landing sites. This process is the most responsive and flexible of all processes considered.

This process is the best capable of servicing multiple customers. A single system would be capable of servicing multiple customers in the vicinity of multiple aerial release points as multiple delivery vehicles dispatch multiple airdrop loads. No other system provides for such a widespread simultaneous delivery capability.

This process is expected to provide the same benefits of reduced risk to delivery personnel when compared to manned systems, the same opportunities for interoperability, and the same level of asset visibility as the other processes considered. This process also equally enables logistic resupply for a noncontiguous operation not capable of being supported by ground lines of communication such as in a multiple island operation scenario.

The disadvantages of this process are that it is the most personnel support intensive, that it requires the greatest footprint, that it is the most complicated of all systems, that this process prevents the most difficult airspace management scenario, and

that, given equal investment of resources, this system is likely to be the least reliable. Personnel would be required to maintain the heavy lift vehicle, the delivery vehicles, and the automated loading system, and the airdrop equipment. Footprint would be required for the heavy lift vehicle, the delivery vehicles, the controllers, and the rigging areas. The various airspaces required by the heavy lift vehicle, the delivery vehicles, and the airdrop cargo itself all require deconfliction with other airspace users. The process' requirement for complicated airborne launch and recovery of delivery vehicles, and the requirement for multiple airdrop system functions, reduce the chance that this system would be as reliable as simpler systems.

PART II. COMPARING POTENTIAL AND EXISTING SYSTEMS

Introduction. To compare the use of unmanned aerial logistic vehicles to other existing modes of delivery, a single supply commodity was singled out. For this commodity, how well the concept of unmanned aerial logistic vehicles would perform was compared to how existing distribution methods perform according to specified criteria. The intent was to determine whether a proof of principle exists that could be expanded to other supply requirements.

For purposes of comparison, the mission of delivering food supplies, Army Supply Class I, was chosen, with the further limitation that only the delivery of Meals-Ready-To-Eat (MREs) was addressed. Deliveries of MREs were selected as the segment of logistic resupply to address as cases of MREs are solid supply commodities that have known and constant height, width, length, and weight. As well, MREs were selected as they have virtually universal demand among deployed US Army units, and other service's members have demand for MREs as well. This segment of the supply system

was able to be clearly defined and limited in scope, yet it retained applicability to the deployed army overall. Virtually all army supply consumers on the battlefield at some point require resupply of MREs.

The existing possible modes of distribution for the delivery of MREs considered included cargo truck delivery of supplies, helicopter sling load of supplies, watercraft delivery, and fixed-wing airdrop and air land of supplies. Cargo truck delivery involves cases of MREs being loaded into the cargo area of the truck and the truck traversing a road network to arrive at its customer location. Helicopter sling load involves cases of MREs being strapped into a cargo sling that hangs suspended from a hook on the bottom exterior of a helicopter as it flies from its pick up supply point to its landing delivery point. Watercraft delivery involves cases of MREs being loaded onto lighters, flat bottomed boats or barges, and transited via self-propelled lighterage or using a tug and barge system from its origin water port to its destination water port. Fixed-wing air drop involves fixed-wing aircraft being loaded with pallets of MREs rigged for airdrop and then the aircraft flying from its origin airstrip to a release point above a customer and the cargo being released to travel by parachute to the customer on the ground. Fixed-wing air land involves cases of MREs being loaded onto fixed-wing aircraft that then take off from the origin airstrip and then fly to and land at its destination airstrip at which point the MREs are discharged from the aircraft while it is on the ground. These existing logistic systems were the ones to which the four potential solution unmanned aerial systems would be compared.

The ground based, manned system, of truck delivery of supplies is the most prevalent resupply system used by the United States Army today. Although watercraft,

helicopters, railways, and fixed-wing aircraft are used to transport supplies, truck delivery is the most predominant and primary means of resupply directly to customer units for the majority of the United States Army's supply needs.

Unmanned aerial vehicles can be compared to ground truck transportation as both systems can pick up from one point and deliver to another point. These two mode compared together do yield advantages and disadvantages for each. However, a limitation of truck resupply is that the system requires a ground line of communication between the source of supply and the customer. Unfortunately, battlefields do not always provide ground lines of communications between sources of supply and customers. Island scenarios involve supply points and customers being separated by water requiring a different mode of delivery to be used. For such scenarios, it made sense to extend the comparison of unmanned aerial vehicle delivery to the existing means of delivery available to address such an island scenario.

Were sources of supply and customers to be separated by bodies of water, existing resupply options involve the use of manned watercraft, helicopter sling load, or fixed-wing airland or airdrop. For this reason, the use of unmanned aerial logistic vehicles was compared to these modes of delivery in the execution of MRE distribution as well.

Similar to the island scenario, likely scenarios exist where some other ground impediment exists between the source of supply and the customer unit, such as the case where the enemy has cut off all ground lines of communication between the source of supply and the customer, and the cases where friendly army units requiring resupply are operating within the enemy's area of control. These scenarios were also considered as the mission of MRE distribution executed by differing modes of distribution was examined.

In the end, each potential unmanned logistic aerial vehicle solution delivering MREs was compared to truck, helicopter sling load, watercraft, fixed-wing airdrop, and fixed-wing airland modes of delivering MREs. The problem criteria were used a means of comparison in each case.

<u>Analysis</u>

In the category of risk to loss of life, the mode involving the greatest risk to life is truck transport as truck transport involves manned systems restricted to moving along linear lines of march. This restriction to use on roads increases the risk of loss of life to the highest level as truck convoys including the truck drivers become the most predictable and able to be targeted of the modes of distribution. Watercraft deliveries risk loss of life as watercraft are restricted to the surface of the water where, although not as restricted to linear routes of travel as much as trucks are, they and their operators remain vulnerable to surface threats, mines or enemy watercraft. Helicopter sling load and fixed-wing air land each involve risk of loss of life, though to a lesser extent than do watercraft and truck distribution. Airways are extremely difficult to mine, whereas roadways and waterways are less difficult to mine. Helicopters and fixed-wing aircraft have a reduction in route predictability as they may use any of the three-dimensionally possible routes between their source of supply and their customer, yet their need to arrive on the ground and take time to discharge their loads makes them additionally vulnerable at that point, particularly when compared to fixed-wing airdrop. Fixed-wing airdrop involves the least risk to life of any of the manned modes as their only vulnerability is while they are in flight and utilizing difficult to predict routes of travel. Each of the four proposed potential unmanned aerial logistic vehicle solutions rate equally the most preferred involving the

least risk to life. At no time along the route between the source of supply and the customer is human life at any risk as the unmanned aerial logistic vehicles are proceeding carrying their cargo load of MREs. The only risks to loss present involve the loss of equipment, the unmanned aerial logistic vehicles, and the loss of supplies, the MREs. Each of the four other modes of delivery (fixed-wing air land, fixed-wing air drop, helicopter sling load, and water craft) all involve risks to loss of life, making them less preferred to unmanned logistic aerial vehicles with respect to this criteria.

In the category of response time, unmanned logistic aerial vehicles equal or better the best performance of the best of the existing modes of transportation. The most responsive existing mode of transportation is airdrop as this mode utilizes flight speeds greater than the speeds of helicopters, trucks, or watercraft. As well, no cargo offload times are required with the use of this mode of delivery. Fixed-wing air land is the next most responsive, utilizing the fastest existing speeds of travel and only adding a bit of additional transport time in the form of time required to offload the cargo at the destination airstrip. Helicopter ranks after fixed-wing airdrop and air land, but better than the slower truck speeds and watercraft speeds involved with those modes of distribution. Watercraft rate the slowest in response time moving at speeds peaking around only 12 knots or 13 miles per hour. All four proposed unmanned aerial logistic vehicle solutions all conceptually use the same airspeed as that of existing fixed-wing cargo aircraft, and the solution where heavy lift ships hover forward of fixed-wing airstrips involve even faster response times as the distance of flight is less using the same speed. Unmanned logistic aerial vehicles are equal, and in some cases much better than existing modes of delivery when considering the criteria of response time. Were one in pursuit of reduced

risks to loss of life and considering implementing the unmanned aerial logistic vehicle concept, no tradeoffs would exist with respect to response time. In fact, in the case of the hovering heavy lift vehicle concept, better response time would be an added benefit.

In the category of versatility, the unmanned aerial logistic vehicle solutions again rank equal to the best of the existing modes of MRE delivery. The most restricted modes are the watercraft mode and the truck mode. Each is restrained to a certain surface: watercraft are restrained to water surfaces, trucks are restrained to land surfaces. Although the restraints on watercraft and trucks can be mitigated through intermodal cargo transfer in coastline areas, the most versatile single modes are the modes exploiting the aerial dimension, helicopter sling load, fixed-wing air land and air drop, and the proposed solutions for unmanned logistic aerial vehicles. These modes all can respond to delivery requirements transiting boundaries between water and land in and of themselves. Were one in pursuit of reduced risks to loss of life and considering implementing the unmanned aerial logistic vehicle concept, no tradeoffs would have to be made with respect to versatility.

In the category of suitability for noncontiguous operations, unmanned aerial logistic vehicles provide capabilities equal to or better than existing modes of distribution. In the scenario where the customer is operating in enemy territory or where the enemy has cut off all ground lines of communication to the customer, watercraft and truck modes of distribution cannot execute the deliveries. In this circumstance, the air modes of resupply must be used, and the unmanned aerial logistic vehicle concept provides the same capabilities as existing air modes of delivery (helicopter sling load, and fixed-wing air land and airdrop) while not risking loss of life. Were existing manned air

resupply systems used and for whatever reason, a system was forced to the ground in the enemy territory that produced the noncontiguous friendly area of operations, a risky rescue effort may have to be undertaken involving additional risk to the loss of friendly life. The unmanned aerial logistic vehicle concept is particularly suited for noncontiguous operations as it can effect delivery without adding additional risks to friendly life during both successful and unsuccessful delivery efforts, as is the case with manned helicopter and fixed-wing resupply operations.

In the category of less-than-truckload resupply operations, the unmanned aerial vehicles concept provides the most efficient possibility for the delivery of less-than-truckload deliveries. Were there a need for a few cases, for example: three cases, of MREs on the battlefield, small unmanned aerial logistic vehicles could be the best possible means of delivery. The use of existing fixed-wing aircraft to deliver only three cases of MREs would waste the remainder of the cargo capacity of the aircraft. The use of a helicopter sling load operation, a watercraft operation, or a truck delivery operation to deliver this example load of three cases of MREs would similarly force the commitment of an entire asset, wasting unused potential cargo capacity. However, were an unmanned aerial logistic vehicle concept developed with just such a cargo carrying capacity, such a means of delivery would meet the requirement without wasting cargo capacity. In such a circumstance, trucks could be left to carry loads being a truckload or greater, while smaller unmanned aerial logistic vehicles could effect delivery of less-than-truck loads. Design effort may not be worth the cost if only MREs are considered as the expected load, but were such an aircraft constructed, not only could the aircraft deliver MREs but it could also deliver small parts, bits of software, or medicines and

other lifesaving medical supplies that may be worth the investment considering the benefits of getting those critical items to the specific place they are needed in rapid order without risking life in the process. Compared to all existing modes considered (fixed-wing, helicopter, watercraft, and truck) the unmanned aerial logistic vehicle concept shows the greatest potential to have the best performance when judged according to the criteria of being able to effect less-than-truckload deliveries on the battlefield.

In the category of complexity, unmanned aerial logistic vehicles rate up to the most complex of delivery modes. None of the proposed unmanned aerial logistic vehicle solutions rate near as well as the least complex existing truck systems of delivery. As noted previously, scenarios where trucks may not be able to perform the mission may occur, in which case fixed-wing or rotary-wing options may have to be exercised. In such circumstances, the first two unmanned aerial logistic vehicle solutions involving takeoff-and-landing and takeoff-and-airdrop are less complex than their manned counterparts. The lack of need for all subsystems added to airframes for cockpit operations yields the unmanned systems reductions in complexity. Reduced complexity typically translates into greater reliability and reduced costs, both preferred characteristics. Trucks are the least complex of systems. Watercraft are the next least simple systems requiring operators trained in navigation and maritime skills, and requiring operators to manage issues of floatation while executing their mission of distribution. From there, the more basic unmanned aerial logistic vehicle concepts are the next least simple, followed by the existing manned rotary-wing and fixed-wing systems. The two proposed solutions involving a heavy lift unmanned aerial vehicle hovering and other unmanned aircraft deploying from it rate the most complex of any mode considered. To reap the less risk to

life responsiveness benefits associated with the more complex unmanned aerial logistic vehicle systems, there is a tradeoff in complexity and expected reliability and cost. However, to reap the less risk to life benefits associated with the less complex unmanned aerial logistic vehicle systems, no tradeoff in complexity need be made. In fact, in these cases, added benefits of reduced complexity and cost may be gained when compared to existing manned rotary-wing and fixed-wing systems.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

This research project was conducted to answer the research question: Could the United States Army benefit by pursuing an unmanned aerial logistic vehicle concept? Having reviewed literature, conducted research, and analyzed the results, the primary conclusion is yes, the United States Army could benefit by implementing an unmanned aerial logistic vehicle concept. This chapter presents conclusions drawn from examining the secondary research questions and an explanation for the project's primary conclusion. The chapter concludes by putting forth recommendations for the United States Army to pursue as it works to implement *Joint Vision 2020* and recommended areas for future research efforts.

Conclusions

The first secondary research question addressed was: Can unmanned aircraft realize a logistic supply delivery process? The conclusion drawn in this area is: yes.

Unmanned aircraft can realize logistic resupply processes. Unmanned aircraft flight is well within the possibilities of today's technology. Over twenty-five models of unmanned aerial vehicles have been designed, tested, and proven successful at conducting unmanned flight. Automated control systems are capable of maneuvering unmanned vehicles with onboard payload through takeoff and ascent to altitude. Unmanned aircraft are capable of flying predetermined routes including those required to get unmanned logistic aerial vehicles within required distances of their customer units. Unmanned aircraft can remotely discharge cargo payload in either an automated fashion or at the command of ground controllers. Payload release from aircraft in flight of cargo

up to 20,000 pounds can be effected without significantly disrupting the flight of the cargo aircraft. Unmanned aircraft are capable of being controlled back to landing airstrips and successfully landed for subsequent use. Unmanned discharged cargo can execute controlled descents under global positioning system guidance to within meters of its targeted landing site. There are no insurmountable technological hurdles involved with unmanned aerial logistic vehicle concept implementation. If pursued, unmanned aircraft can potentially realize logistic resupply processes.

The secondary research question addressed was: Which of the possible unmanned aircraft processes is the recommended process? The conclusions in this area are varied. In certain circumstances, certain processes present certain significant advantages. Processes applied in areas outside their optimum environment present certain disadvantages. An overall conclusion is clear from this examination; however, benefits of unmanned processes in the area of reducing risk to loss of life are present in each process considered.

In circumstances requiring the transport of very heavy cargo loads with weights measured in tons rather than pounds, unmanned ultraheavy lift blimp processes are quite viable processes, much more so than fixed-wing or rotary-wing processes. Blimps' ability to lift up to 160 tons makes them suitable for heavy resupply delivery. Although tradeoffs exist with the use of blimps in the areas of speed and visual signature, the benefits blimps present in terms of unmanned heavy supply delivery via air can be significant.

In circumstances involving restricted ingress and egress to landing and takeoff sites, unmanned helicopters systems are the most viable process, particularly in the case of smaller cargo load delivery. Such circumstances may exist in the army's realm when

having to resupply a unit operating deep within a large city area comprised predominantly of high-rise buildings. The same system would provide benefits in the joint arena as well when resupply between navy ships or between navy ships and shore locations had to be conducted. Helicopter systems, with their vertical takeoff and landing capabilities present the most viable option in such circumstances, although tradeoffs in speed and payload are made when pursuing the unmanned helicopter concept.

In circumstances involving antiair threats, fixed-wing processes are the most viable process option. The speeds attainable by fixed-wing systems allow them to present difficult targets for antiair systems. As well, fixed-wing aircraft's ability to precision airdrop smaller, quiet supply loads from aerial distances offset from their ground target area make this unmanned aerial logistic vehicle system the best suited for areas presenting a significant enemy threat.

The conclusion is made that no matter what set of circumstances can be foreseen to exist on a future battlefield, there is a conceptual unmanned aerial logistic vehicle process suited for executing logistic resupply missions, all providing significant benefits in reduction to risk of loss of life while approaching the delivery site, while executing the supply delivery, and while returning to the source of supply area.

The third secondary research question addressed was: Which existing logistic processes are to be improved? The conclusions reached in this area are that many existing logistic processes can be improved by implementing the unmanned aerial logistic vehicle concept.

Existing manned airdrop logistic processes can be improved by substituting the fixed-wing unmanned aerial logistic vehicle process for the manned process. Benefits

exist in the areas of reduced risk to loss of life, reduced pilot training requirements, and reduced pilot training costs. All hold true in the case where the airdrop systems perform well. In the case of an aircraft malfunction resulting in a crash landing, no urgent rescue operation to recover the aircrew is required in the case of using the unmanned system.

Unmanned helicopter processes yield virtually the same benefits when replacing manned helicopter resupply systems. Substituting unmanned helicopter resupply processes for manned helicopter resupply processes can yield reduced risk, reduced training time, and reduced training costs.

Unmanned blimp resupply processes involving airdrop provide advantages in response time and versatility when compared to existing ground transportation distribution methods. When used, the unmanned blimp resupply processes also reduce the opportunity for enemy interdiction of ground resupply routes.

The overall conclusion drawn in this area is that were an unmanned aerial logistic vehicle system actualized, some part of the existing U.S. Army supply distribution process could be improved. The more unmanned aerial logistic systems actualized, the more benefits gained in comparison to existing resupply systems.

Because unmanned aerial logistic vehicles are feasible from an engineering standpoint, and because unmanned vehicles reduce risk to the priceless lives of soldiers executing logistic resupply missions, and because existing resupply systems could be improved by implementing unmanned aerial vehicle systems, the United States Army could benefit by implementing an unmanned aerial logistic vehicle concept.

Recommendations

The United States Army should pursue development and implementation of the unmanned aerial logistic vehicle concept explored by this project. Once proven in principle, the responsiveness, precision, and supply capabilities of unmanned aerial logistic vehicles will cause the vast array of army unit supply customers to determine to date unforeseen additional applications of the concept. As processes evolve, additional benefits yielded from specialization of delivery systems could be gained. The United States army should pursue each proposed aerial logistic vehicle process until either fruition is achieved or until the point where the expected benefits can not be seen to exceed the costs of development and implementation.

Areas for Recommended Further Research

The number of permutations and combinations of hovering ships, smaller delivery vehicles, forms of air delivery, landing, taking off, and stationing on ground or in air are more numerous than considered by this paper. An optimum solution could likely be found should other combinations or permutations of the concepts considered in this paper be explored.

This project only considered pure blimp, helicopter, fixed-wing, and parachute systems. Hybrid systems could be researched for potential benefits of implementation, including "Dragonfly . . . the canard rotor wing (CRW) concept, in which, after lifting the vehicle vertically, the rotor stops and is locked into place as a wing during cruise, then transitions back to rotor operation for landing" (UAV Forum 2002).

Additional research should be pursued concerning the electronic vulnerability of unmanned aircraft systems. “A very secure, jam-proof data link would have to be developed; and ground control sites would have to be well guarded” (Nordwall 2002).

The modern-day benefits of military unmanned aircraft are seen, particularly in the areas of reconnaissance and ordinance delivery. Today’s technology can effect expansion of the military role of unmanned aerial vehicles to the arena of logistic resupply.

APPENDIX A

CRITERIA APPLIED TO SOLUTIONS

	Potential Solutions			
Criteria in Order of Priority	Solution 1: Load-Takeoff-Land-Unload - blimp, helicopter, or plane	Solution 2: Load-Takeoff-Airdrop-Return	Solution 3: Heavy-lift Ship Takes Off and Hovers-Air Cargo Delivered Via Airdrop	Solution 4: Heavy Lift Ship Takes Off and Hovers-Smaller Delivery UAVs Airdrop and Return
reduced risk to personnel	equal	equal	equal	equal
How well can the process be executed in support of friendly forces operating on a non-contiguous battlefield?	equal	equal	equal	equal
responsiveness	worst	second best	second worst	best
flexibility	worst	second worst	second best	best
reduced footprint	best	second best	second worst	worst
simplicity	best	second best	second worst	worst
personnel requirements	best	second best	second worst	worst
How well can the process service multiple customers?	worst	second best	second worst	best
How well could the process be applied in a joint manner?	best	second best	worst	best
How well can the process execute less-than-truckload delivery?	equal	equal	equal	equal
To what extent is control of the process susceptible to enemy disruption?	best	worst	best	worst
To what extent does the process complicate airspace control?	best	second best	second worst	worst
reliability	best	second best	second worst	worst
lift capability	up to best	up to second worst	up to second best	worst

APPENDIX B

CRITERIA APPLIED TO POTENTIAL AND EXISTING MEANS

	Modes of Distribution								
	Potential Solutions				Existing Means of Distribution				
Criteria	**Solution 1:** Load-Take Off-Land-Unload - blimp, helicopter, or plane	**Solution 2:** Load-Take Off-Airdrop-Return	**Solution 3:** Heavy-lift Ship Takes Off and Hovers-Aircrago Delivered Via Airdrop	**Solution 4:** Heavy Lift Ship Takes Off and Hovers-Smaller Delivery UAVs Airdrop and Return	**Airdrop**	**Airland**	**Watercraft**	**Sling Load**	**Truck**
Risk to Human Life	least	least	least	least	next to least	mid	next to highest	mid	highest
Response time	great	great	great	best	great	great	worst	great	good
Versatility	great	great	great	great	great	great	worst	great	good
Suitability for Non-contiguous Operations	yes	yes	yes	yes	yes	yes	no	yes	no
How well can the process execute less-than-truckload delivery?	can	can	cannot	cannot	not efficiently	not efficiently	cannot	not efficiently	cannot
Complexity	not good	not good	next worst	worst	bad	bad	great	bad	best

REFERENCE LIST

Abel, Timothy W., Captain. 1997. “Is Battlefield Distribution the Answer?” *Army Logistician*, January-February 1997. [article on line]; available from http://www.almc.army.mil/alog/issues/janfeb97/ms093.htm; Internet; accessed 28 October 2002.

Aviation Week & Space Technology and Association for Unmanned Vehicle Systems International 1997-98 International Guide to Unmanned Vehicles. 1997. New York, NY: McGraw-Hill Companies.

Cloud Cap Technology, Inc. *Autopilot Design*. 2001. [design sheet on line]; available from http://www.u-dynamics.com/autopilot/apdesign-datasheet.pdf; Internet: accessed 15 November 2002.

Combat Service Support Element Initiatives. *Guided Parafoil Aerial Delivery System (GPADS) IV-CSSE-1” Experimentation Campaign Plan, 2001*. 2001. [journal on line]; available from http://www.mcwl.quantico.usmc.mil/documents/ecp/ ecp4csse.pdf; Internet; accessed 23 October 2002.

Davis, Stephen R.; Mary E. Denniston; Edward F. Ehlers; John B. Hinson; and Maria Ogden; CPTs. 1997. “Emerging Technology in Airdrop Operations” From: *Quartermaster Professional Bulletin*. Autumn 1997. Fort Lee, VA: Defense Automation and Production Service.

Federation of American Scientists. 2002. “AN/ALE-47 Countermeasures Dispenser System [CMDS]” [article on line]; available from http://www.fas.org/man/dod-101/sys/ac/equip/an-ale-47.htm; Internet; accessed 15 November 2002.

Harrington, Nancy and Edward Doucette. 1999. “Army After Next and Precision Airdrop” From: *Army Logistician* January-February 1999. Fort Lee, VA: Defense Automation and Production Service. [article on line]; available from http://www.almc.army.mil/ALOG/issues/JanFeb99/MS388.htm; Internet; accessed 23 October 2002.

Longino, LT Col Dana A., USAF. December, 1994. *Role of Unmanned Aerial Vehicles in Future Armed Conflict Scenarios.* Maxwell Air Force Base, Alabama: Air University Press.

National Research Council. 2000. *Reducing the Logistics Burden for the Army After Next – Doing More With Less*. Washington, DC: National Academy Press.

Neptune Sciences, Inc. 2002. *Expendable Micro-Sized Environmental Sensor Non-Directional Wave Buoy (XMES-NWB)*. [design sheet on line]; available from http://www.neptunesci.com/; Internet; accessed 15 November 2002.

Nordwall, Bruce D. 2002. “It's Not Simple To Turn Airliners Into UAVs” From: *Aviation Week & Space Technology.* 2002. McGraw-Hill. [article on line]; available from http://www.aviationnow.com/content/publication/awst/20011015/aw69.htm; Internet; accessed 15 November 2002.

Octopus Books. *War Machines Air.* 1977. London: Octopus Books.

Omholt, Ralph. October 16, 2002. “UAVs – A Revolution in Aerial Warfare Continues” From: *DefenseWatch.* October 2002. Soldiers For The Truth. [article on line]; available from http://www.sftt.org/dwa/2002/10/16/2.html; Internet; accessed 24 October 2002.

RAND. *Exploring Microworld Models to Train Army Logistics Management Skills.* [article on line]; available from http://www.rand.org/publications/MR/MR1305/MR1305.ch2.pdf; Internet; accessed 28 October 2002.

Reed, Arthur. 1979. *Brassey’s Unmanned Aircraft.* London: Brassey’s Publishers Limited.

Robinson, Douglas H., and Charles L. Keller, 1982 . *“Up Ship!” - A History of the U.S. Navy’s Rigid Airships 1919-1935.* Annapolis, Maryland: Naval Institute Press.

Sabella, Vito. 2001. *Automated Flight Control of an Unmanned Blimp.* University of Pennsylvania. [journal on line]; available from http://www.ee.upenn.edu/~sunfest/pastProjects/presentations01/vito.pdf; Internet; accessed 15 November 2002.

Swan, Peter F. October 1996. *Trucking Glossary* - University of Michigan Trucking Industry Program. [journal on line]; available from http://www.umich.edu/~trucking/wp/glossary.html; Internet; accessed 16 October 2002.

Systems Victory. [company home page on line]; available from http://www.victory-systems-uav.com/missions-vtoluav-mil.html; Internet; accessed 28 Octyober 2002.

Tactical Control Systems. *Tactical Control Systems Background Brief.* [briefing on line]; available from http://home.navair.navy.mil/tcs/presentations/index.html; Internet; accessed 15 November 2002.

Tactical Control Systems. 5 April 2001. “Tactical Control System Current Developments News Item”[article on line]; available from http://home.navair.navy.mil/tcs/developments/tcspredator.html; Internet; accessed 15 November 2002.

UAV Forum. 2002. *Shadow 600.* [article on line]; available from http://www.uavforum.com/vehicles/production/shadow600.htm; Internet; accessed 15 November 2002.

UAV Forum. *CL-327 Guardian.* [article on line]; available from http://www.uavforum.com/vehicles/production/cl327.htm; Internet; accessed 15 November 2002.

UAV Forum. *Dragonfly*. [article on line]; available from http://www.uavforum.com/vehicles/conceptual/dragonfly.htm; accessed 15 November 2002.

US Department of Defense. 1997. *Joint Vision 2010.* Washington, DC: US Government Printing Office.

_________. 1999. JP 1-02: *Department of Defense Dictionary of Military and Associated Terms.* 1999. Washington, DC: US Government Printing Office.

US Department of the Army. 1994. FM 8-10-14: *Employment Of The Combat Support Hospital Tactics, Techniques, And Procedures.* Washington, DC: US Government Printing Office.

_________. 1996. *Army Vision 2010.* Washington, DC: US Government Printing Office.

_________. 2001. FM 3-0: *Operations.* Washington, DC: US Government Printing Office.

US General Accounting Office. August 1999. *Report to the Secretary of Defense - Unmanned Aerial Vehicles, DOD's Demonstration Approach Has Improved Project Outcomes.* Washington, DC: US Government Printing Office.

US Training and Doctrine Command. February 1998. TRADOC Pam 525-77: *Military Operations -BATTLEFIELD DISTRIBUTION.* Fort Monroe, Virginia: Washington, DC: US Government Printing Office.

Weed, William Speed. 2002. "Flying Blind" From: *DISCOVER* Vol. 23 No. 8 (August 2002). The Walt Disney Company. [article on line] available from http://www.discover.com/aug_02/featflying.html; Internet; accessed 15 November 2002.

INITIAL DISTRIBUTION LIST

Combined Arms Research Library
U.S. Army Command and General Staff College
250 Gibbon Ave.
Fort Leavenworth, KS 66027-2314

Defense Technical Information Center/OCA
825 John J. Kingman Rd., Suite 944
Fort Belvoir, VA 22060-6218

LTC Kenneth E. Long, M.S.
Department of Logistics and Resource Management Operations
USACGSC
1 Reynolds Ave.
Fort Leavenworth, KS 66027-1352

MAJ Marcus D. Majure, M.A.
Department of Logistics and Resource Management Operations
USACGSC
1 Reynolds Ave.
Fort Leavenworth, KS 66027-1352

Ronald E. Cuny, Ed.D.
1812 Evergreen Street
Leavenworth, KS 66048

Headquarters USACASCOM
ATTN: CSS Battle Lab
3901 A Avenue
Fort Lee, VA 23801-1809

Headquarters USATRADOC
ATTN: DCSDCS
Fort Monroe, VA 23651-5000

CERTIFICATION FOR MMAS DISTRIBUTION STATEMENT

1. Certification Date: 6 June 2003

2. Thesis Author: Major John V. McCoy

3. Thesis Title: Unmanned Aerial Logistics Vehicles: A Concept Worth Pursuing?

4. Thesis Committee Members: ______________________________

Signatures: ______________________________

____

5. Distribution Statement: See distribution statements A-X on reverse, then circle appropriate distribution statement letter code below:

A B C D E F X SEE EXPLANATION OF CODES ON REVERSE

If your thesis does not fit into any of the above categories or is classified, you must coordinate with the classified section at CARL.

6. Justification: Justification is required for any distribution other than described in Distribution Statement A. All or part of a thesis may justify distribution limitation. See limitation justification statements 1-10 on reverse, then list, below, the statement(s) that applies (apply) to your thesis and corresponding chapters/sections and pages. Follow sample format shown below:

EXAMPLE

Limitation Justification Statement	/	Chapter/Section	/	Page(s)
Direct Military Support (10)	/	Chapter 3	/	12
Critical Technology (3)	/	Section 4	/	31
Administrative Operational Use (7)	/	Chapter 2	/	13-32

Fill in limitation justification for your thesis below:

Limitation Justification Statement	/	Chapter/Section	/	Page(s)
	/		/	
	/		/	
	/		/	
	/		/	
	/		/	

7. MMAS Thesis Author's Signature: ______________________________

STATEMENT A: Approved for public release; distribution is unlimited. (Documents with this statement may be made available or sold to the general public and foreign nationals).

STATEMENT B: Distribution authorized to U.S. Government agencies only (insert reason and date ON REVERSE OF THIS FORM). Currently used reasons for imposing this statement include the following:

1. Foreign Government Information. Protection of foreign information.

2. Proprietary Information. Protection of proprietary information not owned by the U.S. Government.

3. Critical Technology. Protection and control of critical technology including technical data with potential military application.

4. Test and Evaluation. Protection of test and evaluation of commercial production or military hardware.

5. Contractor Performance Evaluation. Protection of information involving contractor performance evaluation.

6. Premature Dissemination. Protection of information involving systems or hardware from premature dissemination.

7. Administrative/Operational Use. Protection of information restricted to official use or for administrative or operational purposes.

8. Software Documentation. Protection of software documentation - release only in accordance with the provisions of DoD Instruction 7930.2.

9. Specific Authority. Protection of information required by a specific authority.

10. Direct Military Support. To protect export-controlled technical data of such military significance that release for purposes other than direct support of DoD-approved activities may jeopardize a U.S. military advantage.

STATEMENT C: Distribution authorized to U.S. Government agencies and their contractors: (REASON AND DATE). Currently most used reasons are 1, 3, 7, 8, and 9 above.

STATEMENT D: Distribution authorized to DoD and U.S. DoD contractors only; (REASON AND DATE). Currently most reasons are 1, 3, 7, 8, and 9 above.

STATEMENT E: Distribution authorized to DoD only; (REASON AND DATE). Currently most used reasons are 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10.

STATEMENT F: Further dissemination only as directed by (controlling DoD office and date), or higher DoD authority. Used when the DoD originator determines that information is subject to special dissemination limitation specified by paragraph 4-505, DoD 5200.1-R.

STATEMENT X: Distribution authorized to U.S. Government agencies and private individuals of enterprises eligible to obtain export-controlled technical data in accordance with DoD Directive 5230.25; (date). Controlling DoD office is (insert).